

PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

Date of mailing (day/month/year)

23 November 2000 (23.11.00)

International application No.

PCT/GB00/01199

Applicant's or agent's file reference

RECP51232001

International filing date (day/month/year)

29 March 2000 (29.03.00)

Priority date (day/month/year)

29 March 1999 (29.03.99)

Applicant

ZHELUDEV, Nikolay et al

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

27 October 2000 (27.10.00)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland

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Form PCT/IB/331 (July 1992)

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RECP51232001	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/01199	International filing date (day/month/year) 29/03/2000	Priority date (day/month/year) 29/03/1999
International Patent Classification (IPC) or national classification and IPC H01Q7/00		
Applicant HEX TECHNOLOGY HOLDINGS LIMITED et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 7 sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of sheets.</p> <p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input checked="" type="checkbox"/> Certain documents cited VII <input checked="" type="checkbox"/> Certain defects in the international application VIII <input checked="" type="checkbox"/> Certain observations on the international application 		
Date of submission of the demand 27/10/2000	Date of completion of this report 05.07.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Cordeiro, J-P Telephone No. +49 89 2399 8252 	

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/01199

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-7 as originally filed

Claims, No.:

1-2 as originally filed

Drawings, sheets:

1/6-6/6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/01199

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-2
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-2
Industrial applicability (IA)	Yes:	Claims	1-2
	No:	Claims	

2. Citations and explanations
see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

R l t m l

In order to facilitate easy reference the documents cited in the International Search Report are numbered seriatim (i.e. D1 to D3). This numbering will be used in the rest of the procedure.

Re Item V

The description points out the fact that D1 defines a supertoroidal "aerial" (page 4, lines 24-37); The wording used should not be used for differentiating the present feature "super-toroidal conductor" of the present application from the prior art D1 considering its description in D1 on page 6, lines 6 to 21 and the associated figure 1. Furthermore, the present feature is an antenna used as such for transmitting and receiving (see, e.g., page 3, lines 30 to page 4, line 4 & **page 5, lines 10-27** & page 6, lines 7-21 & page 8, lines 29-35 & figures 1a, 1b, 1c);

1. Present independant claim 1, insofar it is clear (see section VIII), does not satisfy the requirements of Article 33(3) PCT because its subject-matter does not involve an inventive step.

- 1.1 Document D1 discloses some of the characteristics described in the claim 1:

- * Apparatus for transmitting information by means of electromagnetic fields in free space (see, e.g., page 3, lines 30-36 & page 5, lines 10-27 & page 6, lines 7-21 & figures 1a, 1b, 1c);
- * An antenna in the form of a super-toroidal conductor including a length of conductor I (see, e.g., page 6, lines 7-21 & figures 1a, 1b, 1c & page 10, lines 23-26);
- * a length of conductor I (see, e.g., page 6, lines 14, 18, 20 & page 10, lines 23-26);
- * An electrical signal generator controllable to produce electrical signals having a selected frequency (see, e.g., page 4, lines 26-32 & page 5, lines 11-15 & page 11, line 35 to page 12, line 2);
- * A modulator to modulate the electrical signals in accordance with the data (information) to be transmitted (see, e.g., page 4, lines 26-32 & page 11, line

35 to page 12, line 2); furthermore, this feature makes part of common knowledge.

1.2 The subject-matter defined in the independent claim 1 differs from document D1 in the coupler used between generator and antenna; this coupler used to feed the antenna is however a well known feature in the art for such applications.

1.3 Independent claim 1 is therefore not inventive (Article 33(3) PCT).

2. Present independent claim 2, insofar it is clear (see section VIII), does not satisfy the requirements of Article 33(3) PCT because its subject-matter does not involve an inventive step.

2.1 Document D1 discloses some of the characteristics described in the claim 2:

- * Apparatus for receiving information transmitted by means of electromagnetic fields in free space (see e.g., page 5, lines 11-27 & page 10, lines 1-6 & figures 1a, 1b, 1c);

- * An antenna in the form of a super-toroidal conductor having a length of conductor l (see, e.g., page 6, lines 8-21 & figures 1a, 1b, 1c & page 10, lines 23-26);

- * a length of conductor l (see e.g., page 6, lines 14, 18, 20 & page 10, lines 23-26);

- * A receiver controllable to receive electrical signals having a selected frequency (see e.g., page 5, lines 11-27 & page 10, lines 2-6 & page 11, line 35 to page 12, line 2);

- * Electrical signals produced in the antenna due to information with electromagnetic fields carrying the transmitted information (see e.g., page 5, lines 11-27 & page 6, lines 17-21 & page 10, lines 2-6 & page 11, line 35 to page 12, line 2); furthermore, this feature makes part of common knowledge.

2.2 The subject-matter defined in the independent claim 2 differs from document D1 in:

- * A coupler in between antenna and receiver;

- * A detector for detecting the information from the electrical signals;

The coupler used in between the antenna and receiver is a well known feature in the art employed in such application.

Furthermore, the use of a detector is necessary to extract the information from the electromagnetic signal and is implicitly present in D1 (see, e.g., page 5, lines 11-27 & page 6, lines 17-21 & page 10, lines 2-6 & page 11, line 35 to page 12, line 2 & page 12, lines 28-32 & table 4).

2.3 Independant claim 2 is therefore not inventive (Article 33(3) PCT).

Re Section VI

Having regard to Rule 64.3 PCT, the Applicants attention is drawn to document **D3 = WO 99/19936** which has been published after the relevant date referred to in Rule 64.1 PCT, but was filed before the priority date of the present application.

The Examiner is unable to verify the priority of the current application document. The Applicant is therefore notified that the document **D3 = WO 99/19936** cited as a 'P' document in the International Search Report would attack inventive step of the claims of the current application, if the priority was invalid.

Re Item VII

1. To set out the independant claims in the correct two-part form, the precharacterising part should have been based on the nearest prior art (for instance D1) (Rule 6.3 (b) PCT).
2. Citation D1 should have been referred to in the description as representing the relevant prior art (Rule 5.1 (a) (ii) PCT).
3. References should have preferably been used in the claims (Rule 6.2 (b) PCT).

Re Item VIII

1. Claims 1 and 2 do not meet the requirements of Article 6 PCT in that the matter for

which protection is sought is not defined.

- The statement '*...a super-toroidal conductor including/having a length of conductor l...*' is vague because it does not clearly define the length *l*. Moreover, the description appears to be clearer concerning the definition of the said length on page 4, lines 24 to 27 and page 6, lines 1 to 6.
- The length of the conductor being unclear, the lower limit of the frequency is therefore also unclear whenever the description appears to be clearer on this point (page 6, lines 1 to 6).

2. In claims 1 and 2, the imprecise statement "...at least...not less than $2c/l$..." is unclear (Article 6 PCT) when used to interpret it (see the PCT Guidelines, C-III, 4.5 a).
3. In claim 1, the coupler couples the energy from the generator to the antenna which appears to be in disagreement with the drawing (figure 6) which shows a coupler coupling the modulator to the antenna (Article 6 PCT).
4. In claim 2 (lines 25 to 29), the statement "electrical signals produced in the antenna ... from the electrical signals." is broadly defined rendering the subject matter for which protection is sought unclear whereas the description appears to be clearer on this point (page 6, lines 17-30).
5. The description defines the modulator which modulates or "transforms" the signals (see e.g., page 5, lines 7-8); The wording "transforms" should not have been used considering its broad and vague meaning (Article 6 PCT).

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference RECP51232001	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 01199	International filing date (day/month/year) 29/03/2000	(Earliest) Priority Date (day/month/year) 29/03/1999
Applicant HEX TECHNOLOGY HOLDINGS LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the language, the International search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the International search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of invention is lacking (see Box II).

4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1b _____

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/01199

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q7/00 H01Q11/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 03850 A (VAISER LEONID VLADIMIROVICH ;KOKORIN BORIS IVANOVICH (HU)) 9 February 1995 (1995-02-09) cited in the application page 1 page 5-7 claims 5,6,14-19; figures 1A-1C, ---	1,2
A	US 5 734 353 A (VAN VOORHIES KURT LOUIS) 31 March 1998 (1998-03-31) cited in the application column 6, line 16-67 column 10, line 45-55 column 12, line 51-59 column 20, line 57 -column 22, line 6; claims 36-39; figures 1-14,21,58,68,69,76 --- -/-	1,2

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

° Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"Z" document member of the same patent family

Date of the actual completion of the international search

5 June 2000

Date of mailing of the international search report

14/06/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Ribbe, J

INTERNATIONAL SEARCH REPORT

International Application No

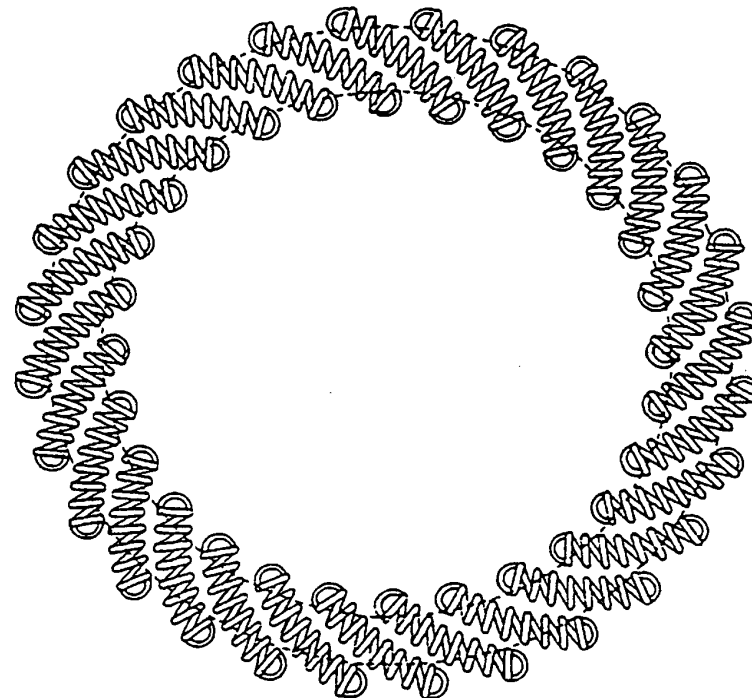
PCT/GB 00/01199

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X, L	<p>WO 99 19936 A (HEX TECHNOLOGY HOLDINGS LIMITE; KOKORIN BORIS IVANOVICH ; CROSS RUP) 22 April 1999 (1999-04-22) page 5, line 30 -page 6, line 23 page 14, line 30-35; claims 1-10, 22; figures 1A-1C, 3-5</p> <p>-----</p>	1, 2



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : H01Q 7/00, 11/08	A1	(11) International Publication Number: WO 00/59069 (43) International Publication Date: 5 October 2000 (05.10.00)
(21) International Application Number: PCT/GB00/01199 (22) International Filing Date: 29 March 2000 (29.03.00) (30) Priority Data: 9907253.0 29 March 1999 (29.03.99) GB (71) Applicant (for all designated States except US): HEX TECHNOLOGY HOLDINGS LIMITED [-/-]; 40 Esplanade, P.O. Box 301, St. Helier, Jersey JE4 8UG (GB). (72) Inventors; and (75) Inventors/Applicants (for US only): ZHELUDEV, Nikolay [GB/GB]; 50 Basset Crescent West, Southampton SO16 7DX (GB). KOKORIN, Boris Ivanovich [RU/GB]; 10 Kerrifield, Winchester, Hampshire SO22 5EX (GB). (74) Agent: BOULT WADE TENNANT; Verulam Gardens, 70 Gray's Inn Road, London WC1X 8BT (GB).		(81) Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: TRANSMITTING AND RECEIVING APPARATUS (57) Abstract <p>An antenna for transmitting information by means of electromagnetic fields in free space is formed as a supertoroidal conductor, comprising a helical coil of wire with the coil itself being wound helically around a toroidal former to form a toroidally shaped coiled coil. Higher orders of supertoroid are formed by replacing the wire of the above first order supertoroidal conductor with ahelical coil. The supertoroidal antenna is energised from a signal generator generating signals including frequencies not less than $2c/l$, where l is the length of conductor in the supertoroidal antenna. Both transmitting and receiving arrangements are disclosed.</p> 		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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- 1 -

TRANSMITTING AND RECEIVING APPARATUS

The present invention relates to transmitting and receiving apparatus and particularly to apparatus for transmitting information by means of electromagnetic fields in free space and for receiving such information.

Radio frequency transmitters and receivers employ a wide range of antenna types. Different types of antenna may be used depending on the requirements of the transmitting and receiving system. For example, line of sight transmission between two fixed points may employ narrow beam transmitting and receiving antennae, such as dish antennae (for UHF and microwave frequencies), and multi element arrays for UHF and lower frequencies. In other applications, omni-directional antennae are required, for example for mobile communications and for radio positioning systems using fixed beacons.

There is also a requirement in some systems for antennae to be operable over a relatively broad band of frequencies. Apart from military applications generally, there are increasing applications for spread spectrum transmission systems for which wide band antennae may be highly desirable.

A further requirement of antennae systems, especially those which are required to be portable, is that they be as small and compact as possible.

U.S. Patent No. 5734353 discloses a contra wound toroidal helical antenna made from a single continuous conductor divided into two length portions each of which are substantially the same length and which have a generalised helical pattern. The helical pitch senses in the two length portions are opposite one another. The two length portions are insulated from one another and overlap one another on the surface of a generalised toroid former. The antenna is said to have vertical polarisation with a radiation pattern similar to an electric dipole, but in a physical

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package that is substantially smaller.

According to the disclosure, the antenna is intended to operate with a moderate band width (10 to 20%) around a resonant frequency. The resonant
5 frequency is determined in relation to the geometry of the toroidal conductor so that the circumferential length of the toroidal helical antenna is one half of a guided wavelength. From the examples given in this patent specification, a toroidal helical antenna with
10 a total helical conductor length of about 3 metres has a resonant frequency of operation at around 30 MHZ. At such a frequency, the toroidal antenna would have a major diameter of about 50 cms. Higher operating frequencies would employ a antenna of smaller diameter
15 and vice versa.

Similar contra wound toroidal helical antenna structures are disclosed in U.S. Patent Nos. 5654723, 5442369, 4751515 and 4622558.

The present invention provides apparatus for
20 transmitting information by means of electromagnetic fields in free space comprising an antenna in the form of a super-toroidal conductor including a length of conductor l , an electrical signal generator controllable to produce electrical signals having at
25 least a selected frequency which is not less than $2c/l$ where c is the speed of light in free space, a coupler to couple said electrical signals from said generator to energise said antenna for launching the electromagnetic fields to transmit the information,
30 and a modulator to modulate the electromagnetic fields launched by the antenna in accordance with the information to be transmitted.

Whilst a toroidal helical conductor, as known in the aforementioned prior art specifications, is one in
35 which the conductor is wound helically around a toroidal former, a super-toroidal conductor is one in which the windings of a toroidal helical conductor are themselves constituted as helical windings. In a first order super-toroidal winding, the conductor of

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the toroidal helical winding of the prior art is replaced by a long helically coiled conductor which is itself wound around the toroidal former. In a second order super-toroidal winding, the conductor of the first order super-toroidal winding is replaced by a long helically coiled conductor, and so forth up to higher orders. All references herein to windings being helical in form should be construed as references also to other windings providing a generally poloidal form.

Energising an antenna in the form of a super-toroidal conductor as set out above, at the relatively high frequencies specified, has been found to provide surprising and useful results in the field of the transmission of information by electromagnetic fields. In particular, when energised at the higher frequencies indicated, the antenna has been found to have extremely broad band characteristics, extending over at least one doubling of frequency. Furthermore, an antenna in the form of a super-toroidal conductor energised as indicated is not only omni-directional in an azimuthal plane parallel to the plane of the torus, but also provides substantial emission in directions parallel to the major axis of the torus, i.e. perpendicular to the azimuthal plane.

The invention also provides apparatus for receiving information transmitted by means of electromagnetic fields in free space from a distant source, the apparatus comprising an antenna in the form of a super-toroidal conductor having a length of conductor l , a receiver controllable to receive electrical signals having at least a selected frequency which is not less than $2c/l$ where c is the speed of light in free space, a coupler to couple, from the antenna to the receiver, electrical signals produced in the antenna due to information with electromagnetic fields carrying the transmitted information, and a detector for detecting the information from the electrical signals.

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Examples of the invention will now be described with reference to the accompanying drawings in which:

Figures 1a and 1b are schematic views of a super-toroidal conductor winding in the plane of the torus, and along the major axis of the torus respectively;

Figure 2 is a view of part of the torus of the winding of Figure 1 illustrating a super-toroid of second order;

Figure 3 is a view of part of the torus of a super-toroidal winding of third order;

Figure 4 is a graphical plot illustrating the emission efficiency of a super-toroidal antenna of second order;

Figure 5 is a graphical plot illustrating the emission efficiency of a super-toroidal antenna of third order;

Figure 6 is a block schematic diagram illustrating a transmitter embodying the present invention; and

Figure 7 is a block schematic diagram illustrating a receiver embodying the present invention.

Super-toroidally wound conductors have been described in WO 95/03850. This specification discloses super-toroidal windings of various orders including second and third order windings, in applications for detecting and generating forms of electromagnetic field associated with living organisms and non-living bodies, and also for producing fields for treating such organisms and bodies. Although the specification refers to the super-toroidal windings as "aerials" in fact the specification nowhere contemplates using such devices for the transmission or reception of information by modulating information at a transmitter and by detecting the transmitted information at a receiver.

In accordance with an embodiment of the present invention, a second order super-toroidal conductor as

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illustrated in Figures 1 and 2 is used as the transmitting antenna of a radio transmitter for sending information to a remote receiver. Referring to Figure 6, the transmitter may comprise an rf
5 generator or a pulse generator 10 supplying radio frequency signals or electric pulse signals to a modulator 11. The modulator 11 modulates or transforms the signals from the generator 10 in accordance with data to be transmitted supplied to the
10 modulator on line 12. The modulated or transformed signals are then supplied by means of a coupler 13 to energise the super-toroidal antenna 14.

In accordance with a feature of the present invention, the transmitter using the super-toroidal
15 antenna 14 is arranged to energise the antenna 14 at frequencies substantially above those frequencies at which the current in all segments of the super-toroidal winding of the antenna 14 would have substantially the same phase. It may be understood
20 that prior art toroidal helical antennae have been energised at frequencies such that the magnetic field induced around the circumference of the torus at any instant in time has the same direction around the torus at all points around the torus. This is
25 necessary if the prior art toroidal helical antennae are to substantially reproduce the effect of a linear electric dipole. In accordance with the embodiment of the present invention, the rf generator 10 is arranged to produce radio frequency signals at frequencies
30 substantially higher than those which could produce a uniform circumferential magnetic field around the torus at any time.

It has been found that at such higher frequencies, the super-toroidal antenna embodying the
35 present invention has very broad band attributes. In addition, the antenna is not only omni-directional in the azimuthal plane of the torus of the antenna, but produces substantial transmission in directions parallel to the major axis of the torus.

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An appropriate lower limit for the frequency of signals to be supplied to the super-toroidal antenna of Figure 6 is the frequency at which the wavelength in free space of electromagnetic radiation would be half the total length of the conductor forming the super-toroidal antenna. In one example, a first order super-toroidal antenna has a conductor length of 20 metres. The operating frequency range preferably has a lower limit of 30 MHZ, and preferably extends to several hundreds of MHZ, and even to several GHZ.

If the antenna 14 is formed of a second order super-toroidal winding, the wire length is typically 84 metres, implying a lower frequency limit of about 7 MHZ. A third order super-toroidal antenna having a conductor length of 210 metres could be used down to about 2.8 MHZ.

Figure 7 illustrates a receiver embodying the present invention. In Figure 7, electromagnetic fields modulated with information from a remote source interact with a super-toroidal antenna 15 which is connected via a coupler 16 to a receiver and detector circuit 17. The receiver 17 is adapted to receive signals from the antenna 15 at frequencies higher than frequencies corresponding to a free space wavelength of half the conductor length of a super-toroidal antenna 15. The detector in the receiver and detector circuit 17 is arranged to detect modulation of the received signals so as to derive from the received signals the data being transmitted from the remote source and supply this data on an output line 18.

Figure 4 illustrates the performance of a second order super-toroidal antenna in various orientations. In Figure 4, the heavy line 20 is a plot of the emission efficiency of the second order super-toroidal antenna in directions parallel to the plane of the torus of the antenna, over frequencies ranging from zero to several GHZ. The fine solid line 21 in the Figure is a plot of the emission efficiency of the antenna in directions parallel to the major axis of

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the torus of the antenna. A further plot 22 of the emission efficiency of a commercial spiral log antenna is provided for comparison purposes.

Figure 5 illustrates the emission efficiency with frequency of a third order super-toroidal antenna. In this Figure, the fine solid line 30 plots the emission efficiency of the antenna in directions parallel to the plane of the torus, and the heavy line 31 plots the emission efficiency in directions parallel to the major axis of the torus.

In Figure 6, the super-toroidal antenna 14 is illustrated as coupled by direct connection to opposite ends of the conductor forming the super-toroidal winding of the antenna. Other forms of coupling to the transmitting or receiving antennas can be contemplated. For example connections may be made at multiple points around the torus of the winding. Alternatively, the windings may be energised capacitively by plates located close to the windings at different points around the torus. Different coupling arrangements may be preferred for matching the impedance of the antenna to the feeding or receiving circuitry as appropriate.

Rather than a continuous helix, the winding of the antenna may be formed in sections which may be connected together or separately energised. The winding may also be formed using double or multiple conductors, possibly wound with opposite hand.

It should be understood that the torus used as the former of the antenna need not be a body of revolution and is not necessary circular in radial section, but has generally toroidal topology.

Further the helicity of the winding of the antenna may have different sign at different levels of the super-toroidal structure, and/or different sign in different sections of the same level. Clearly, the windings illustrated in the Figures are only examples.

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CLAIMS:

1. Apparatus for transmitting information by means of electromagnetic fields in free space comprising an antenna in the form of a super-toroidal conductor including a length of conductor l , an electrical signal generator controllable to produce electrical signals having at least a selected frequency which is not less than $2c/l$ where c is the speed of light in free space, a coupler to couple said electrical signals from said generator to energise said antenna for launching the electromagnetic fields to transmit the information, and a modulator to modulate the electromagnetic fields launched by the antenna in accordance with the information to be transmitted.

2. Apparatus for receiving information transmitted by means of electromagnetic fields in free space from a distant source, the apparatus comprising an antenna in the form of a super-toroidal conductor having a length of conductor l , a receiver controllable to receive electrical signals having at least a selected frequency which is not less than $2c/l$ where c is the speed of light in free space, a coupler to couple, from the antenna to the receiver, electrical signals produced in the antenna due to information with electromagnetic fields carrying the transmitted information, and a detector for detecting the information from the electrical signals.

30

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FIG. 1a.

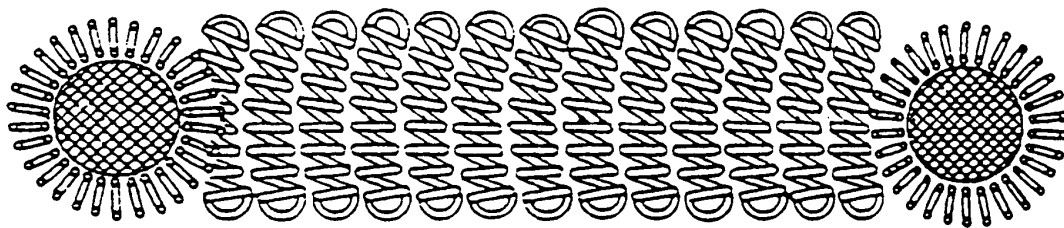
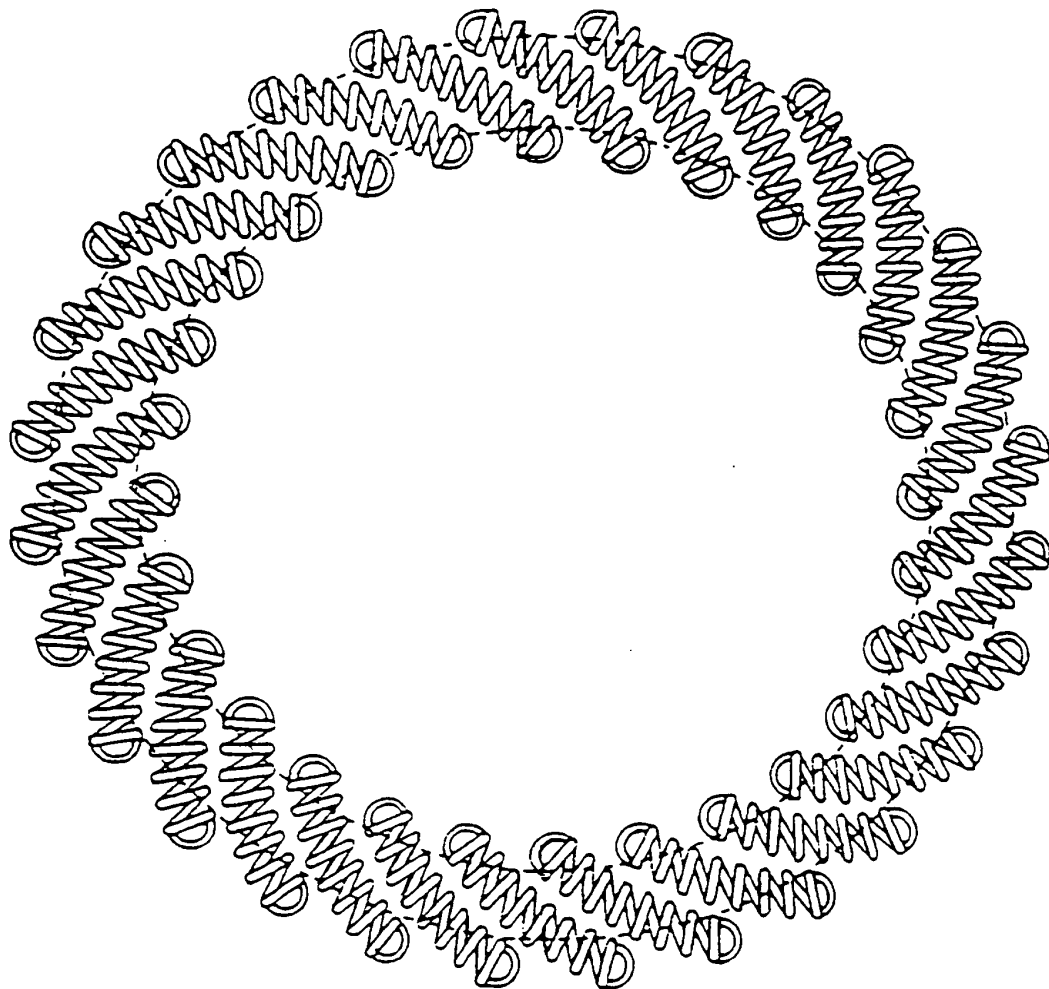
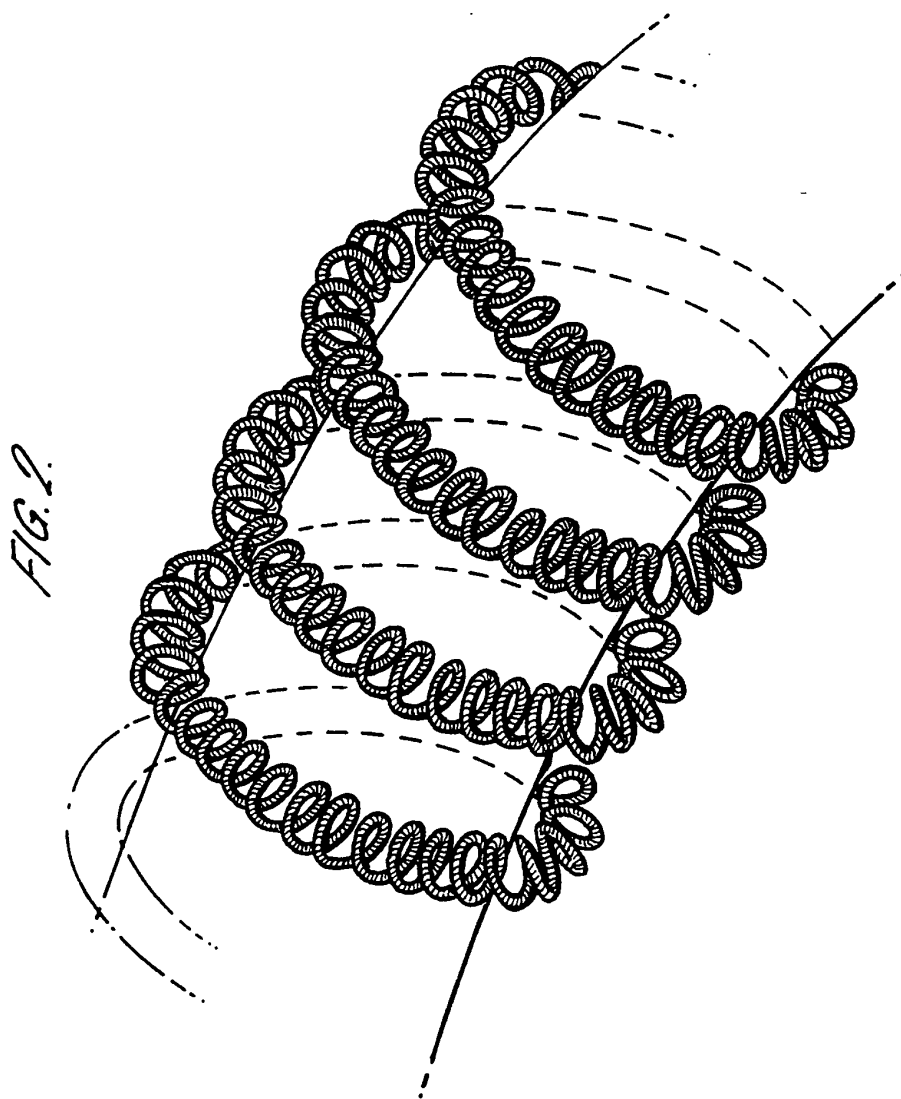


FIG. 1b.





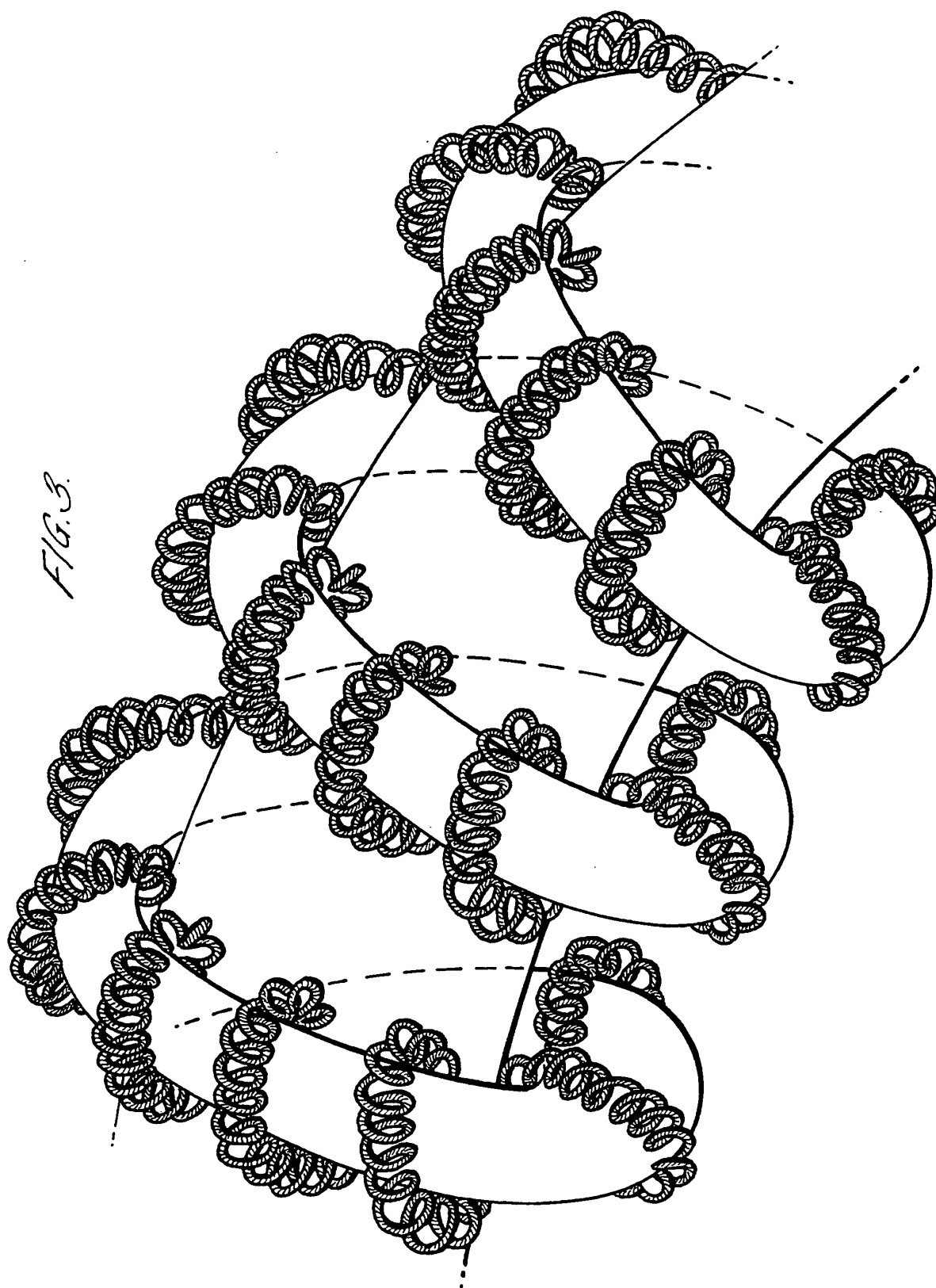


FIG. 4. STA order 2 EMISSION EFFICIENCY FOR 2 ORIENTATIONS
+ EMISSION EFFICIENCY FOR A COMMERCIAL SPIRAL LOG ANTENNA

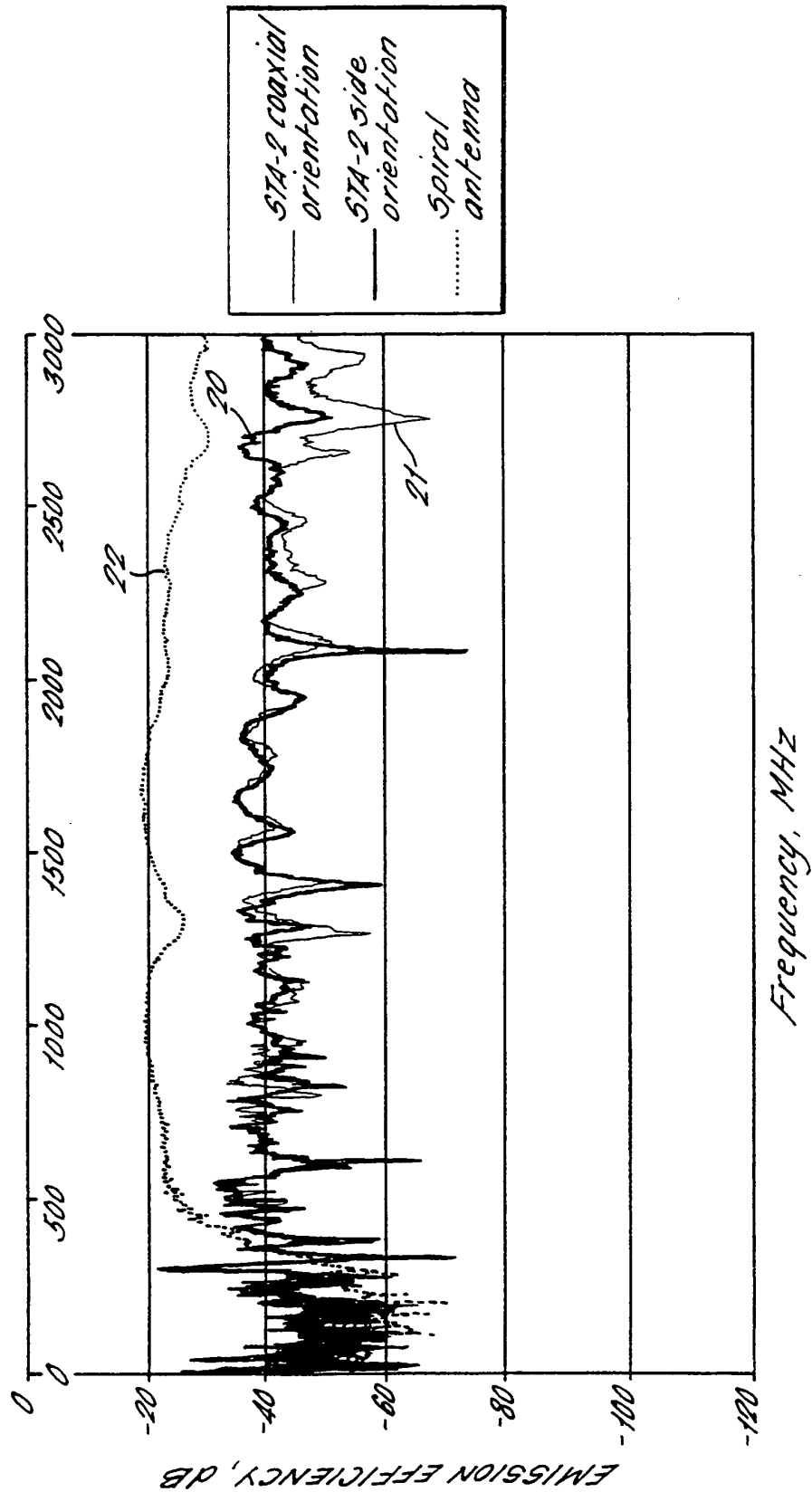
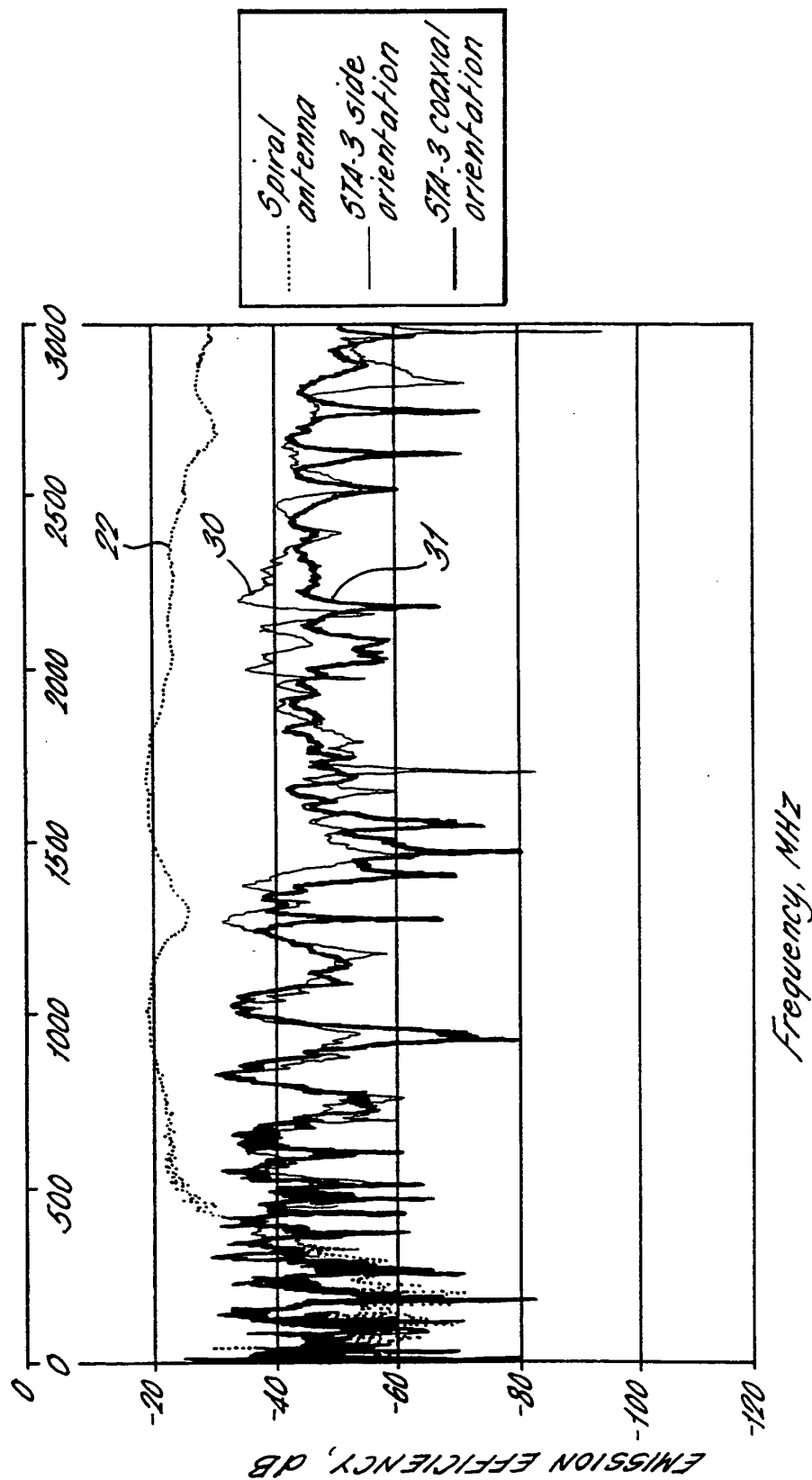
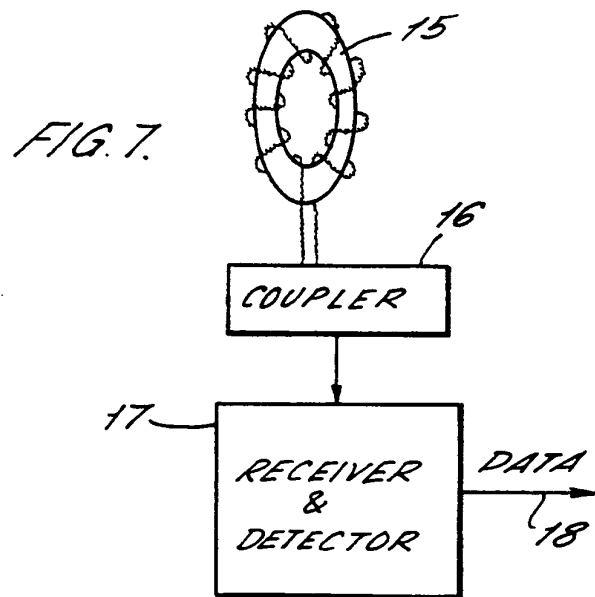
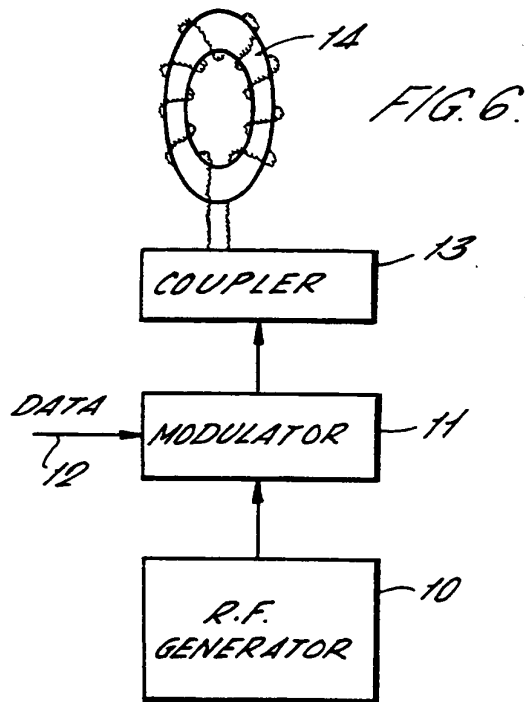


FIG. 5. STA order 3 EMISSION EFFICIENCY FOR 2 ORIENTATIONS
+ EMISSION EFFICIENCY FOR A COMMERCIAL SPIRAL LOG ANTENNA



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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/01199

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q7/00 H01Q11/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 03850 A (VAISER LEONID VLADIMIROVICH ;KOKORIN BORIS IVANOVICH (HU)) 9 February 1995 (1995-02-09) cited in the application page 1 page 5-7 claims 5,6,14-19; figures 1A-1C,	1,2
A	US 5 734 353 A (VAN VOORHIES KURT LOUIS) 31 March 1998 (1998-03-31) cited in the application column 6, line 16-67 column 10, line 45-55 column 12, line 51-59 column 20, line 57 -column 22, line 6; claims 36-39; figures 1-14,21,58,68,69,76 -/-	1,2

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- *&* document member of the same patent family

Date of the actual completion of the international search

5 June 2000

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/GB 00/01199

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